High Contrast Imaging of Extrasolar Planets with a Vector Vortex Coronagraph

Completed Technology Project (2013 - 2017)

Project Introduction

The discovery of rocky planets orbiting their parent stars in the habitable zone, the area where the temperature is such that water is able to exist in liquid form, is one of the most compelling goals in astrophysics and a top priority of NASA's Science Mission Directorate. Rocky, habitable-zone planets around the stars nearest to the sun would be the most important discoveries, as they would be most amenable to study from powerful space-based instruments like the James Webb Space Telescope. None have yet been found, even though studies have convincingly demonstrated that they should be extremely common. The most promising method of finding these planets is through Doppler velocimetry, where a star's radial velocity is analyzed for the characteristic back-and-forth motion caused by an orbiting planet. State-of-the art instruments are able to detect stellar velocities just under 1 meter/second, the speed of a human walking. Despite this achievement, this level of precision is about a factor of ten larger than the signal of an Earth-like planet orbiting a Sun-like star. The precision of the best instruments is generally limited by the inability to compensate for tiny changes in temperature, pressure, and illumination of the optics, all of which can masquerade as velocity shifts and swamp the low signals of orbiting planets. For the next generation of instruments, whose design precisions approach or exceed the ~10 cm/s necessary to detect small, rocky planets, these noise sources will be extremely important to characterize and control. I propose to develop novel devices and methods to calibrate, test, and improve the performance of ultra-high precision Doppler velocimeters. These devices will simulate velocity shifts on real light, whether calibration light or starlight, using optomechanical and acousto-optical techniques. I propose to use these devices to help achieve the design goals of two instruments I am working on: Minerva, an automated, distributed-aperture robotic observatory dedicated to precision Doppler velocimetry every night; and LAEDI, a novel combination of an interferometer and spectrograph. If they reach their design precision, both of these instruments will be able to detect rocky, habitable-zone planets around nearby stars.

Anticipated Benefits

The discovery of rocky planets orbiting their parent stars in the habitable zone, the area where the temperature is such that water is able to exist in liquid form, is one of the most compelling goals in astrophysics and a top priority of NASA's Science Mission Directorate. This project aims to develop novel devices and methods to calibrate, test, and improve the performance of ultra-high precision Doppler velocimeters. This project aims to use these devices to help achieve the design goals of two instruments: Minerva and LAEDI. If they reach their design precision, both of these instruments will be able to detect rocky, habitable-zone planets around nearby stars.

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Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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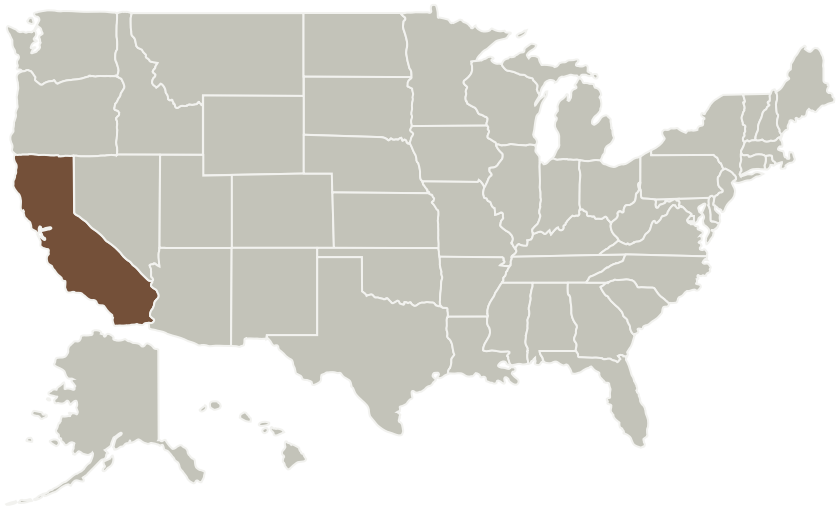
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Project Management

Program Director:
Claudia M Meyer

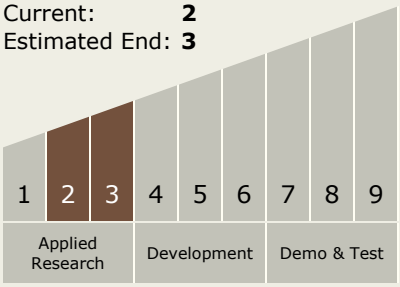
Program Manager:
Hung D Nguyen

Principal Investigator:
Shrinivas Kularni

Co-Investigator:
Michael Bottom

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes